

Source Control for Pharmaceuticals in Wastewater

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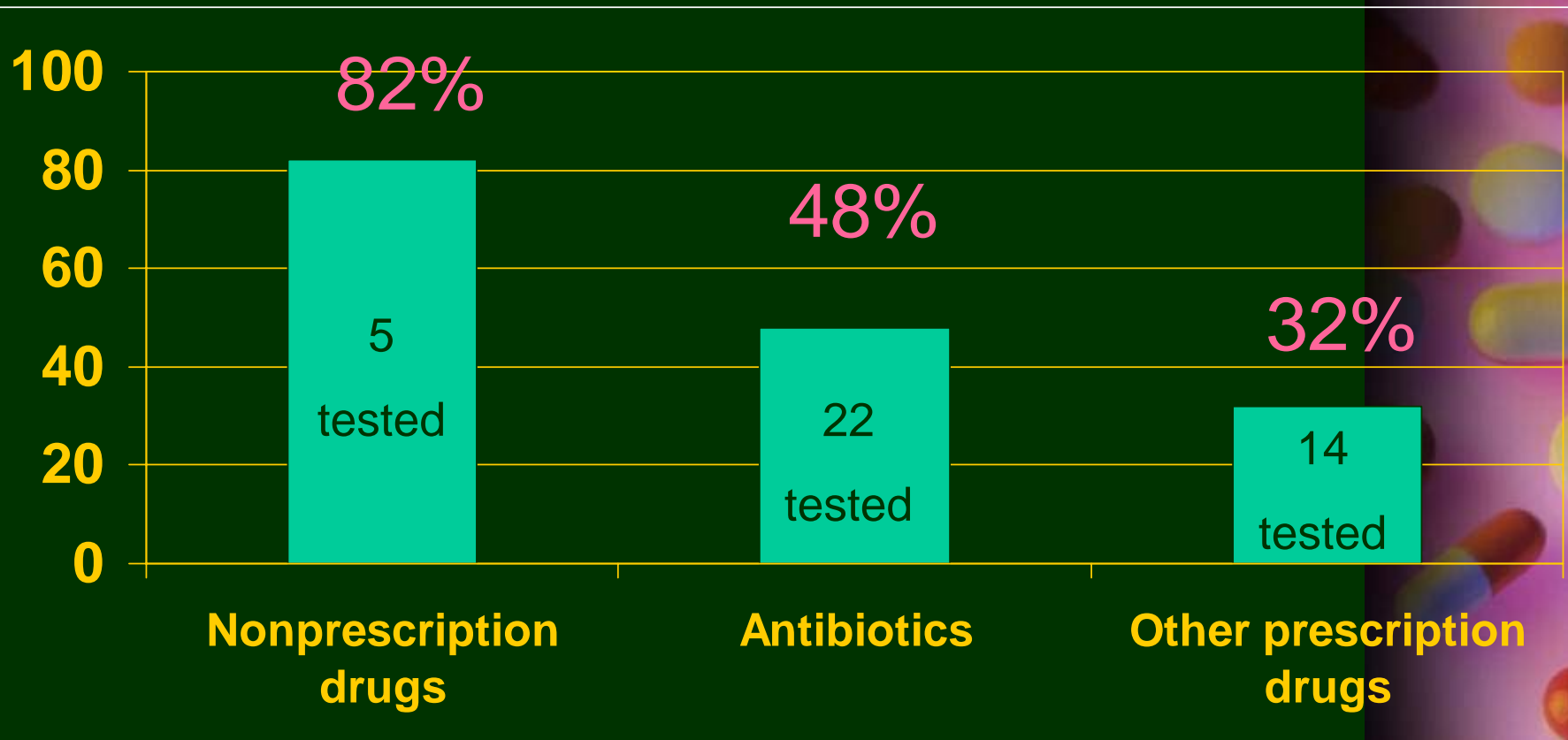
US Waterways are Impacted!

- USGS Analyzed 139 streams- 80% of samples analyzed one or more of pharmaceuticals
 - Acetaminophen (24%)
 - Steroids and hormones (16%)
 - Diltiazem (blood pressure medication) (13%)
 - Codeine (11%)
 - Antibiotics and antimicrobials (10%)
 - Ibuprofen (10%)



USGS Stream Survey

Frequency of Detection by Drug Class



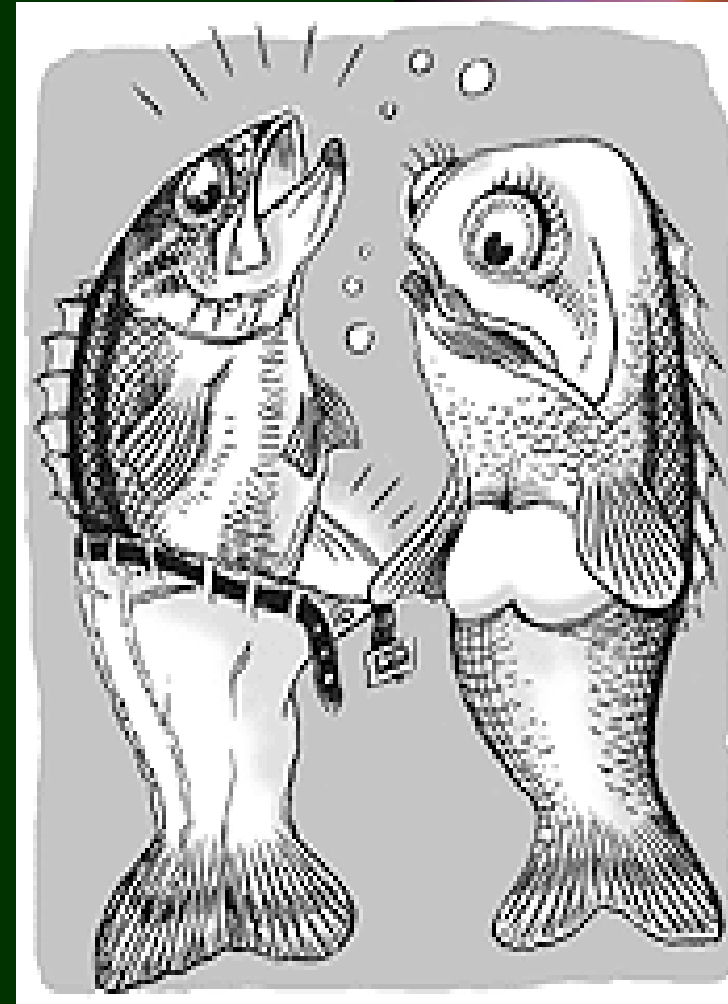
Why do we care?

- Potential effects to organisms
 - Endocrine disruption
 - Synergistic effects
 - Possible toxicity
- Precautionary Principle
 - Pharmaceuticals should not be in the aquatic environment
 - Limited toxicological information on pharmaceuticals less than 1% of active ingredient products
- Creation of “superbugs”



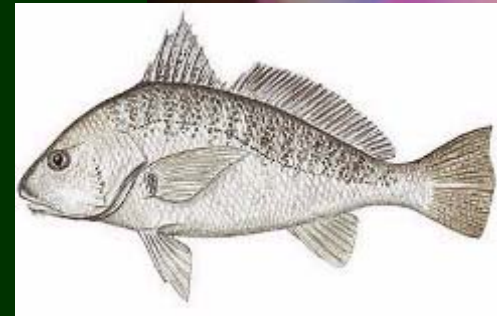
17alpha ethynyl estradiol

- Synthetic estrogen
- Present in 16% of rivers in USGS study
- Median concentration 73 ng/l
- Vitellogenin production (feminization) in male fish
- Effects at concentrations as low as 1 ng/l
- Feminization of male fish in Lake Mead & UK linked to estrogens



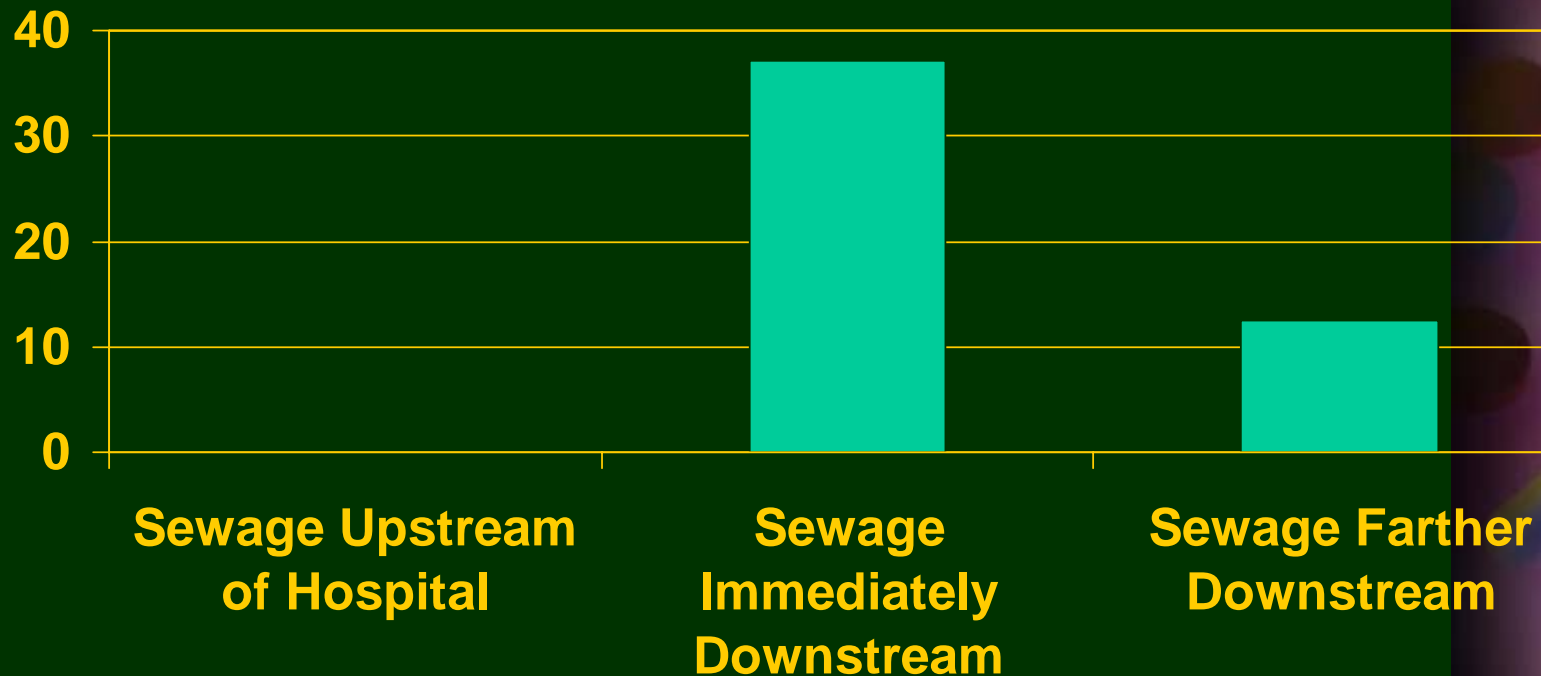
Other Endocrine Disruptors

- SSRIs (antidepressants) induce spawning in shellfish
- Calcium channel blockers (used to lower blood pressure) dramatically inhibit sperm activity in Atlantic croaker
- Clofibrate (used to lower cholesterol) caused high production of estrogen in juvenile zebra fish at concentrations present in Chesapeake Bay



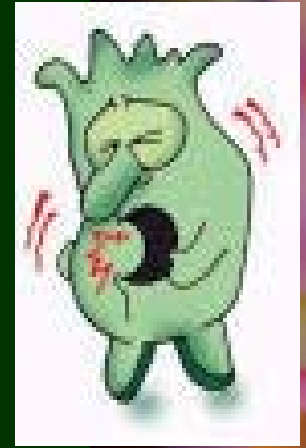
Antibiotic Resistance

Percent of Resistance to Oxytetracycline in
Acinetobacter Isolates, Danish Study



Antibiotic Resistance

- Ampicillin-resistant bacteria found in every U.S. river tested in a 1999 study
 - 4 - 59% of population resistant
 - Significant numbers contained plasmids, which may be transferable to other organisms
- All samples of Ohio River water and two tributaries, contained E. coli with some degree of resistance to penicillin, tetracycline, and vancomycin in a 2000 study
 - Samples containing the highest levels of antibiotics also contained bacteria with greatest resistance



Persistence of Pharmaceuticals

- B-blocker nadolol and antibiotic amoxicillin 80-90% excreted unchanged
- Persistence in environment due to constant discharge
 - Antiepileptic drug carbamazepine
 - 50% breaks down after 82 days under semi-field conditions (Lam et al 2003)



How Pharmaceuticals get into the Environment

- Wastewater treatment plants that treat household, industrial, and business
- Industrial dischargers
- Commercial animal feeding operations
- Surface application of biosolids

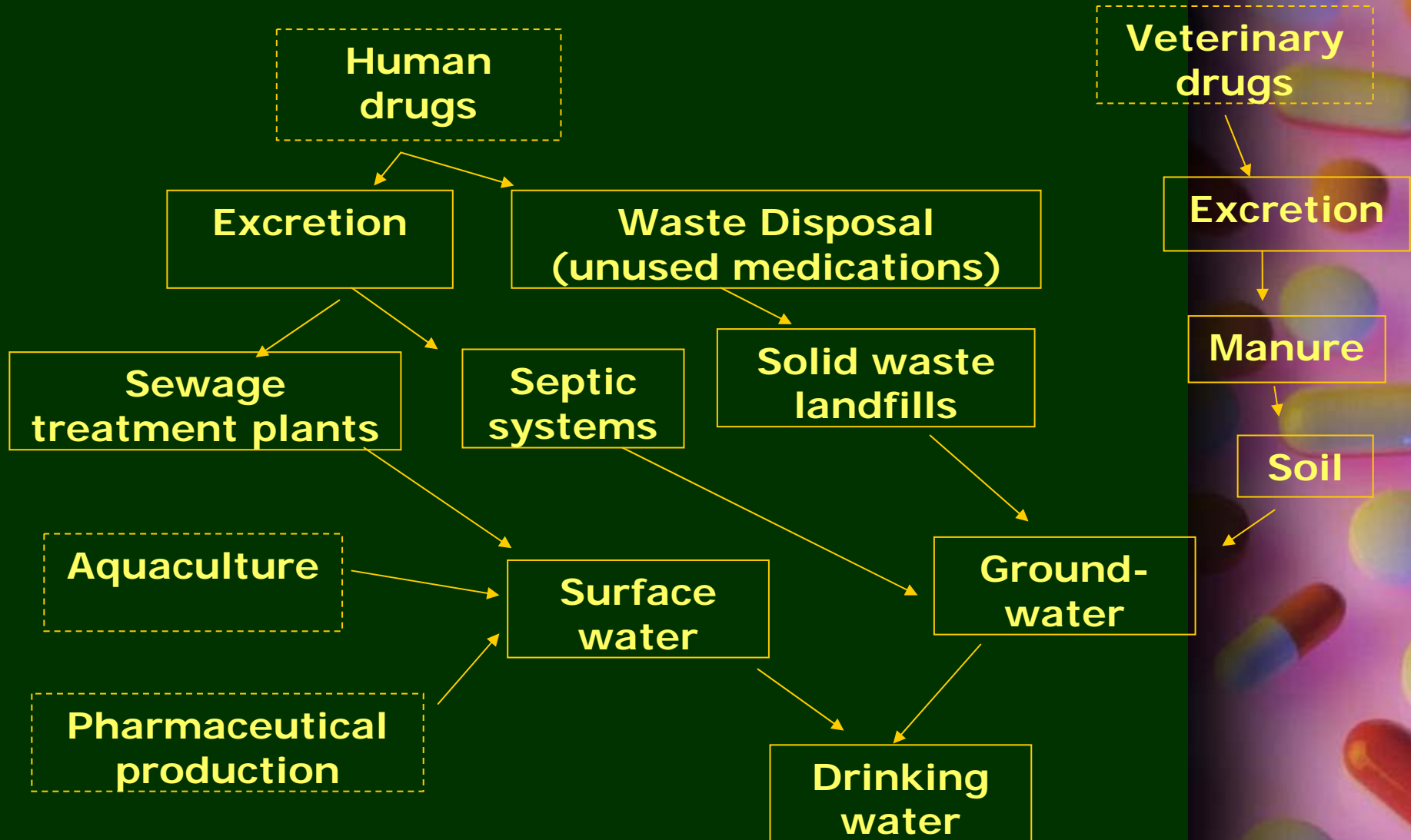


Drug Portal to the World



adapted by Daughton from Ternes (April 20

Sources and Pathways



Excretion Percentages – Top 10 US Pharmaceuticals in 2003

- Lipitor - cholesterol reduction – < 2% excreted
- Zocor – cholesterol reduction – < 0.5% excreted
- Prevacid – ulcers - < 1% excreted
- Procrit – anemia – < 5% excreted
- Zyprexa – antipsychotic – 7% excreted
- Epogen – anemia – < 5% excreted
- Nexium – acid reflux - < 1% excreted
- Zoloft – antidepressant – 14% excreted
- Celebrex – anti-inflammatory - < 3% excreted
- Neurontin – antiseizure – 100% excreted
- Leading OTC drug: Ibuprofen – 10% excreted



Removal Rate at WWTPs

- Sex hormones reduced by 68%
- Natural steroids and synthetic hormones are removed at 38-83%
- The majority of compounds are predicted to be removed via the sludge phase



Major Sources of Pharmaceutical Waste

- Regulated
 - Hospitals
 - Pharmacies
 - Assisted living facilities
 - Veterinary hospitals
 - Dentists
- Unregulated
 - Residents
 - Hospice patients



Residential Pharmaceutical Waste



Who regulates residential pharmaceutical waste?

- Department of Health Services
 - Do not regulate residential pharmaceuticals, have no jurisdiction over residential medical care
- Department of Toxic Substances
 - Do not regulate residential pharmaceutical waste, even if it is classified as a hazardous waste
- Drug Enforcement Agency
 - Out of the closed loop system no longer regulated
- U.S. Food and Drug Administration
 - Approve drugs, do not care about end of life



Residential Disposal of Pharmaceutical Waste

- Unregulated
- Pharmacies are not required to take-back unused/ expired medications
- Traditionally, two disposal options
 - Down the drain
 - Trash
- Now have other options
 - Household Hazardous Waste Events
 - Working on other options for residents



Other Programs

- Return unwanted medicine (RUM) program in Australia
 - > 30 tons collected in 2004
 - 20 million people
 - Since 1998 – funded by government with approximate cost of 1 million per year
- California ~ population 35 million
 - Implies that we have greater than 30 tons of pharmaceuticals being disposed of incorrectly every year!



Current Pilot Programs

- Palo Alto hosts take back at Senior Centers
 - Collected 75 lbs of pharmaceuticals during 3 day event
 - Only advertised at Senior Centers
- County of Marin
 - Take back at 5 pharmacies
 - 2 months one 8 gallon container of waste pharmaceuticals
- State of Maine – one Saturday collected at pharmacy
 - 52 people approximately 50 gallons one day event
 - USEPA collaborated with Police, Northeast Recycling Council, Maine EPA and Pharmacy



Return of Medications (survey at pharmacies in UK)

- Majority of items returned from people over 60 years old
- Reasons for return
 - Medication stopped
 - Patient died
 - Excess supply or clear out
 - Medication stopped by patient
 - Adverse effect from drug
 - Most returns within a year of being prescribed



Residential Pharmaceuticals

Potential Actions	Anticipated Challenges	Next Steps
Discourage disposal in toilets or sinks	Funding; prioritization amongst other clean water agencies	NGOs encouraged to educate residents on this topic
Encourage disposal at HHW events	Funding for HHW programs prior to region-wide campaign	Local HHW and POTWs are encouraged to communicate about local funding constraints
Take-back programs at pharmacies	Buy-in from pharmacies, HMO pharmacies, and drug store chains/businesses; funding	Local pilot programs are encouraged
Take back events at senior centers	Coordinate with HHW programs or haulers	Educate seniors and provide take-back options
Take back events or programs with Fire/Police	Buy-in from fire or police department; funding	Local agencies may wish to collaborate with Fire/ Police to pilot a take-back event

Next Steps

- Wastewater agencies work with HHW programs to develop an easy drop-off alternative for residents
- Further Research
 - Hospice Patients
 - Drug Enforcement Agency
- Future Legislation Options



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